

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of)	
)	
Mitigation of Orbital Debris in the New)	IB Docket No. 18-313
Space Age)	

**COMMENTS OF
THE BOEING COMPANY**

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SUMMARY

The commercial space industry is experiencing a period of tremendous growth and innovation, with U.S. companies in leadership roles in many of these initiatives and American citizens ultimately receiving the benefits of the services they make possible. To maintain this growth and leadership, steps must be taken by industry participants and government to ensure that orbital debris does not inhibit the progress of commercial enterprises in space. At the same time, the Commission's regulatory measures in this area must be balanced as compared to the activities of other countries in order to ensure that the rules applicable to U.S. satellite operators do not create a competitive disadvantage for U.S. businesses in addressing an issue that is truly global in scope. Further, the Commission must remain cognizant that it is not the lead expert agency within the U.S. government on these highly technical issues. Therefore, the Commission should refrain from adopting any additional rules governing orbital debris absent careful coordination with other U.S. federal agencies with expertise in these areas, including federal agencies that operate their own satellite systems and employ researchers that specialize in this field.

The Commission should also refrain from adopting any additional orbital debris rules that require satellite license applicants to disclose information to the Commission regarding the planned operations of their satellite systems without concurrently providing objective guidance regarding the manner in which such information will be assessed by the Commission staff and how they will determine which operations and numeric values are presumptively acceptable. Such guidance is important to ensure that the Commission's orbital debris rules are transparent and predictable for U.S. satellite licensees.

With this background, Boeing addresses in these comments the following specific issues identified within the Commission's notice of proposed rulemaking:

- Uncoupled launch deployment mechanisms can provide important public interest benefits to prevent the inadvertent creation of orbital debris and therefore, the Commission should not adopt information disclosure requirements for these devices absent a clear statement regarding when their use should be permitted. (§§ 20-21)
- New types of liquid propellants are providing important public interest benefits for the commercial space industry and the Commission should not adopt information disclosure requirements regarding their identities unless such information can be kept confidential and criteria is established for their permissible use. (§§ 22-23)
- The Commission should add transparency and predictability to its existing rules by adopting the NASA standard that each satellite should be designed such that it presents a probable risk of a collision with a large object of no more than 0.001. Consistent with the NASA recommendation, this metric should be adopted on a per satellite basis. (§ 26)
- To add further transparency and predictability to its rules, the Commission should adopt the NASA standard that each satellite (on a per satellite basis) should be designed such that it presents a probable risk of no more than 0.01 of becoming a source of orbital debris as a result of a collision with small objects. (§ 27)
- The Commission should update its disclosure requirements for non-geostationary satellite orbit (“NGSO”) systems to require coordination with all other NGSO systems the normal operation of which could be effected by the proposed system. (§ 28)
- The Commission should require the operators of NGSO systems proposing to operate above the nominal altitude of the International Space Station (“ISS”) to disclose any operational constraints that may be caused to the ISS or other manned spacecraft. The Commission, however, should not adopt this new information disclosure requirement unless it concurrently adopts objective criteria regarding the avoidance measures that would be presumptively sufficient to warrant Commission approval. (§ 30)
- Regardless of the reason, the Commission should not attempt to regulate the business and technical decisions of satellite operators regarding the selection of orbits for proposed satellites, including seeking information regarding why an orbit above 650 kilometers may be chosen. (§ 31)
- If the Commission adopts an information disclosure requirement regarding the length of the deorbit process for a proposed satellite, it should adopt presumptive criteria for what is acceptable, possibly based on the proposed orbital altitude of the satellite. (§§ 32, 58-59)
- The Commission should not adopt rules addressing the potential use of highly congested orbits because the Commission’s other orbital debris reporting requirements are sufficient to address collision avoidance in congested orbits. (§ 33)

- The Commission should not require that all NGSO satellites operated above a certain altitude must have propulsion capabilities because other techniques are available to enable collision avoidance maneuvers. (§ 34)
- In order to conserve scarce orbital resources, the Commission should adopt requirements that large NGSO systems adhere to their proposed orbits within certain identified limits. (§ 35)
- The Commission should continue to give NGSO system operators discretion whether to use active or passive tracking methods and, if active, the characteristics of the tracking signal. (§ 36)
- The Commission should require satellite operators to provide information to the U.S. Strategic Command's Joint Space Operations Center (or any successor organization) regarding the initial deployment, ephemeris data and any planned maneuvers for its satellites. (§ 37)
- Boeing has no objection to a Commission requirement that NGSO satellite applicants certify they will take steps to mitigate collision risk, although all satellite operators already have sufficient incentives to avoid collision risks. (§ 38)
- The Commission should not adopt information disclosure requirements regarding the number of avoidance maneuvers expected for NGSO satellite systems unless the Commission adopts presumptive criteria regarding the acceptable frequency of such maneuvers or refrains from using the information it receives to withhold or condition licenses. (§ 39)
- Given the record of success and the public interest benefits of launching multiple satellites on the same launch vehicle, the Commission should not adopt information disclosure requirements regarding these practices. (§§ 40-41)
- The Commission should not adopt design and fabrication reliability requirements for large NGSO satellite systems, particularly on the order of 0.999 or better, because such restrictions would impede innovation and harm U.S. space leadership. (§§ 42-43)
- The Commission should adopt presumptive reliability metrics of 0.9 per satellite and as high as 0.95 for individual satellites in large constellations (those with 100 satellites or more) regarding the disposal measures that will be employed for atmospheric re-entry of NGSO satellites. (§ 46)
- The Commission should not require the launch of NGSO satellites to an initial altitude of below 650 kilometers because the use of a few test satellites operating at the intended orbit provides a more reliable and cost effective means to ensure the reliability of spacecraft designs. (§ 48)
- The Commission should not require NGSO satellites to automatically initiate disposal procedures in the event of a loss of power or communications because such measures

are unlikely to be successful and other methods (such as redundancy in critical systems) would be more effective in preventing debris. (§§ 49-50)

- The Commission should continue to encourage the development of technologies capable of directly retrieving satellites, but such technologies are not yet reliable or cost effective and should not yet be incorporated in the FCC's rules. (§§ 53-54)
- The Commission should adopt casualty risk requirements that are consistent with NASA standards, including with respect to assessing all objects with an impacting kinetic energy in excess of 15 joules and applying that metric on a per satellite or per debris basis (*i.e.*, assessing each surviving component from a satellite separately). If the Commission adopts the NASA standard, it should also adopt the NASA metric that 0.0001 is presumptively acceptable. (§§ 60-61)
- The Commission should codify its policies regarding license extensions for geostationary ("GSO") satellites and permit multiple extensions and extensions of longer than five years if warranted. (§§ 64-66)
- The Commission should not adopt special disclosure requirements for satellites engaged in proximity operations because such issues are addressed sufficiently in the Commission's other debris mitigation rules (such as collision avoidance methods) and such activities should be encouraged to promote U.S. space leadership. (§ 68)
- The Commission should update its rule for orbit raising to cover both GSO and NGSO satellites on a fully coordinated basis and eliminate the requirement that transiting satellites must operate on a non-interference and unprotected basis. (§§ 70-71)
- The Commission should require all NGSO system operators to make their ephemeris data available to other NGSO system operators using any reasonable method identified by the NGSO system operator rather than mandating any particular disclosure method. (§§ 72-73)
- The Commission should refrain from imposing encryption requirements on satellite command signals because satellite operators already have sufficient incentive to protect their space assets through encryption if warranted. (§§ 74-75)
- The Commission should not impose indemnification requirements on satellite licensees because no evidence exists that the U.S. government has ever faced any financial loss as a result of an accident involving a U.S. licensed satellite and, in the unlikely event of such an accident, the U.S. would be protected adequately through a civil court claim of contribution against the satellite operator. (§ 78)
- The Commission should not impose insurance requirements on satellite licensees because such insurance likely would not provide incentives toward heightened orbital debris mitigation and the absence of an insurance requirement has not resulted in unrecovered liability for the U.S. government or individuals. (§ 80)

- The Commission should not adopt regulations that seek to reduce the number of satellites that are launched under U.S. jurisdiction because such measures would only push the commercial space industry overseas without mitigating orbital debris. (§ 92)
- The Commission should not attempt to regulate the design of satellite systems or components because such measures would extinguish the growth of the U.S. commercial space industry, ceding this leadership to other countries. (§ 93)
- The Commission should not require satellite operators to engage in active debris cleanup since this technology is not yet ready for use in a reliable and cost effective manner. (§ 97)

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**COMMENTS OF
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The Boeing Company (“Boeing”) herein provides these comments on the Notice of Proposed Rulemaking (“*NPRM*”) addressing updates to the Commission’s rules regarding the mitigation of orbital debris.¹

Boeing has a tremendous vested interest in ensuring that orbital debris does not impede the rapid growth and development of the global satellite industry, both for commercial and government purposes. Boeing is a world leading manufacturer of satellites and other aerospace systems. More than two dozen of Boeing’s flagship 702 geostationary (“GSO”) spacecraft are currently operating in space, with more than a dozen more 702 spacecraft currently in production. In 2018, Boeing completed its acquisition of Millennium Space Systems, which serves the interests of customers seeking small and medium sized satellites, including its Altair spacecraft, which is modular and scalable in conformance with the Cubesat format, and its larger Aquila spacecraft with a one cubic meter payload capacity.

¹ See Mitigation of Orbital Debris in the New Space Age, *Notice of Proposed Rulemaking*, FCC 18-159 (Nov. 19, 2018) (“*NPRM*”).

Boeing is also an applicant for authority to launch and operate a non-geostationary satellite orbit (“NGSO”) system. Boeing’s NGSO system would operate using V-band frequencies and would encompass two constellations of NGSO satellites operating in a coordinated basis, one set in low Earth orbit (“LEO”) and a second set operating in a highly inclined orbit near geostationary altitude. This combination would enable the provision of high speed broadband communications to customers wherever they are located, while also providing the benefits of very low latency through LEO communications.

Boeing’s diverse interests in space extend well beyond satellites. For example, Boeing has been NASA’s prime contractor for the International Space Station (“ISS”) program for more than two decades, with assignments including building 43,000 cubic feet of pressurized living and working space – the equivalent of the interior volume of two 747s. As NASA’s leading contractor, Boeing also built the Shuttle Orbiters and their main engines, prepared the Shuttle’s payloads, and performed integration for the overall Shuttle system. The company also is working with NASA on the development of Boeing’s Commercial Crew Transportation spacecraft, the CST-100 Starliner, which may begin missions to the ISS starting in 2019.

Boeing is also the leading U.S. exporter of aerospace products and services, contributing significantly to the U.S. economy and its balance of trade with foreign countries. Boeing employs more than 140 thousand people, the vast majority of which are in highly skilled positions in U.S.-based facilities located in 49 states. In furtherance of these interests and for the benefit of the economic and technical leadership of the United States, Boeing provides the following comments.

I. THE COMMISSION SHOULD EXERCISE CAUTION IN ENSURING THAT ANY RULES ADOPTED IN THIS PROCEEDING ARE ALIGNED FULLY WITH THE COMPETITIVE GOALS OF THE ADMINISTRATION

The U.S. government has repeatedly recognized that the United States is in a highly competitive race with other major countries in the commercial use of space to support numerous industries and initiatives, including our critical interests in homeland security. The President's National Space Council ("NSC") recommended in its February 2018 report that the National Telecommunications and Information Administration ("NTIA") and the Commission coordinate to ensure the protection and stewardship of the spectrum necessary for commercial space activities.² President Trump further emphasized the importance of this goal, directing the NSC, in cooperation with other federal agencies, including the Commission, to prepare a report on "improving the global competitiveness of the United States space sector through radio frequency spectrum policies, regulation, and United States activities at the International Telecommunication Union and other multilateral forums."³

These efforts are centered around the need to ensure the United States maintains its leadership in the exploration and commercial exploitation of space. As U.S. Commerce Secretary Wilbur Ross recently explained, "[t]he United States is experiencing a significant revival of its space industry."⁴ As a result, the global space economy now totals almost \$400 billion and

² See <https://spacepolicyonline.com/wp-content/uploads/2018/02/WH-press-release-NSpC-Recs-Feb-21-2018.pdf> (Recommendation 3).

³ Presidential Memoranda, *Space Policy Directive-2, Streamlining Regulations on Commercial Use of Space*, at Sec. 5b (May 24, 2018) available at <https://www.whitehouse.gov/presidential-actions/space-policy-directive-2-streamlining-regulations-commercial-use-space/>.

⁴ Remarks by Commerce Secretary Wilbur L. Ross at the Department of Commerce Space Investment Summit (Dec. 12, 2018) available at <https://www.commerce.gov/news/speeches/2018/12/remarks-commerce-secretary-wilbur-l-ross-department-commerce-space-investment> (last visited March 14, 2019).

is set to grow rapidly to \$1 trillion a year in annual revenue.⁵ The U.S., however, is not alone in this resurgence. As Secretary Ross cautioned “more than 70 countries are now engaged in the global space industry, with more entering the market every year.”⁶

To maintain U.S. leadership in the commercial space industry, the Commission should exercise caution in ensuring that any additional rules addressing orbital debris that are adopted in this proceeding are closely coordinated with the initiatives of other federal agencies and do not diverge appreciably from the orbital debris standards and recommendations being adopted by the international community.

Clearly, mitigation of orbital debris is an important undertaking. This said, the U.S. government Space Policy Directive (“SPD-3”), which is heavily quoted in the *NPRM*, explains that “the U.S. Government should streamline processes and reduce regulatory burdens that could inhibit commercial sector growth and innovation, enabling the U.S. commercial sector to continue to lead the world in [space traffic management]-related technologies, goods, data, and services on the international market.”⁷ Consistent with this, the U.S.—through the Commission and other federal agencies—should work within the international community to develop international standards and best practices that can then be adopted domestically in coordination with other

⁵ *See id.*

⁶ *Id.*

⁷ Space Policy Directive-3, National Space Traffic Management Policy, Presidential Memorandum (June 18, 2018), *available at* <https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/> (*last visited* March 26, 2019) (“SPD-3”).

countries.⁸ Only in this way can the United States successfully address what is truly a global issue.

The exercise of significant caution in this undertaking is particularly important given the fact that the Commission is not the lead expert agency on the highly technical issues discussed in the *NPRM*. As the Commission acknowledges, “several agencies examine the impact of potential space debris in space operation authorizations”⁹ including NOAA, NASA, NTIA, the FAA, the Department of Transportation, the Department of Commerce, and the Department of Defense. Several of these federal agencies operate their own space systems, and commission and oversee technical studies on these issues, and employ scientists and researchers that develop standards and recommendations on orbital debris mitigation issues. Thus, although the Commission may have a role in regulating the mitigation of orbital debris by FCC licensees, this role must be coordinated closely with the findings of other U.S. federal agencies with targeted expertise in these areas.

II. THE COMMISSION SHOULD REFRAIN FROM ADOPTING ANY NEW INFORMATION DISCLOSURE RULES UNLESS THEY ARE TIED TO SPECIFIC REGULATORY CRITERIA

When the Commission first adopted its orbital debris mitigation rules in 2004, the text of the rules largely required satellite license applicants to affirm that they had “assessed and limited” the probability of creating orbital debris.¹⁰ The rules also required the disclosure of the details

⁸ See *id.* at Sec. 5(c)(iii) (explaining that “[t]he United States should encourage the adoption of new norms of behavior and best practices for space operations by the international community through bilateral and multilateral discussions with other spacefaring nations, and through U.S. participation in various organizations such as the Inter-Agency Space Debris Coordination Committee, International Standards Organization, Consultative Committee for Space Data Systems, and UN Committee on the Peaceful Uses of Outer Space”).

⁹ *NPRM*, ¶ 2.

¹⁰ See 47 C.F.R. § 25.114(d)(14).

regarding these assessment and mitigation measures, including providing certain demonstrations and analysis results.¹¹ The rules, however, did not include specific thresholds regarding the amount of mitigation that was sufficient and acceptable to warrant the Commission's approval.

The Commission's rules were originally drafted in this manner to give the FCC staff flexibility to assess each application on a case-by-case basis.¹² Over time, however, the FCC staff developed internal norms regarding what they considered to be sufficient and acceptable and these requirements were communicated to satellite license applicants on an informal basis.

Although this approach provided the FCC staff which much needed flexibility while they increased their knowledge base regarding the mitigation of orbital debris, it is questionable whether this informal approach was consistent with the requirements of administrative procedure. It is therefore encouraging that the *NPRM* proposes to substantially amend Section 25.114(d)(14) of the Commission's rules to codify many of the requirements that may have been previously imposed on satellite license applicants on an informal basis. For example, the proposed rules specify the types of analysis that must be conducted to assess certain conditions (*i.e.*, requiring calculations using either the NASA Debris Assessment Software or a higher fidelity model) and the minimum probability statistics for other requirements (*i.e.*, a probability of 0.001 or less that a space station will become a source of debris by collision with large debris). Such rules should provide further transparency and predictability to the Commission's licensing process.

Further, now that the Commission's knowledge base in the field of orbital debris has increased, the Commission should avoid the adoption of any additional information disclosure rules unless those requirements are coupled with a specific criteria that can be used by license

¹¹ *See id.*

¹² *See NPRM*, ¶ 6.

applicants and the FCC staff in determining what is sufficient and acceptable. In urging this approach, Boeing is not seeking to eliminate the Commission's case-by-case approach to satellite licensing. Boeing acknowledges that the rapid growth and evolution of the commercial space industry makes it extremely difficult to adopt specific rules that can anticipate every future proposal and condition.

Nevertheless, in each case in which the Commission adopts a new information disclosure requirement, the Commission should concurrently provide guidance regarding its presumptive expectations with respect to the required substance of a disclosure and what would presumptively be acceptable. In this manner, the Commission will maintain its appropriate role as the supervisory body that formulates regulations for implementation by FCC staff, rather than codifying requirements that were previously implemented informally.

It is with this background that Boeing provides the following comments on each of the proposals put forth by the *NPRM* for new rules and requirements that would be imposed primarily on U.S. operators of satellites and launch systems.

A. The Commission Should Not Adopt Information Disclosure Requirements for Uncoupled Deployment Mechanisms Absent a Clear Statement Regarding When Their Use Should be Permitted

As the *NPRM* acknowledges, instances exist when satellite operators and launch providers use deployment mechanisms during the launch process either to prevent multiple satellites from damaging each other, or to initiate their separation from the launch vehicle.¹³ The *NPRM*

¹³ See *id.*, ¶ 20.

observes that these devices become orbital debris immediately upon completion of the satellite deployment and therefore the *NPRM* asserts that their use “should be minimized.”¹⁴

At the same time, the *NPRM* acknowledges that uncoupled deployment devices can provide important public interest benefits in avoiding the creation of additional orbital debris.¹⁵ For example, the use of separating devices between multiple satellites in the same launch vehicle can help prevent the satellites from damaging each other, thus avoiding satellite components from separating from the satellite, or the catastrophic loss of an entire spacecraft. Also, as the *NPRM* notes, devices that enable the launch of multiple satellites on the same launch vehicle reduce the number of launches required to complete a constellation,¹⁶ ultimately reducing both the creation of orbital debris and the airborne pollutants resulting from each launch.

Given these competing costs and benefits that are inherent in using uncoupled deployment mechanisms, the Commission should not adopt an information disclosure requirement for these devices unless it also adopts a presumptive threshold regarding when their use is warranted. For example, the Commission should conclude that the use of uncoupled deployment mechanisms is justified if the applicant can demonstrate that the use of such devices will create less orbital debris than potentially could result absent their use. In this way, satellite license applicants will benefit from a transparent and objective standard that they can use when designing satellite launch systems and when preparing FCC applications seeking their approval.

¹⁴ *Id.*

¹⁵ *See id.*, ¶ 21.

¹⁶ *See id.*

B. The Commission Should Not Adopt Information Disclosure Requirements Regarding the Potential Release of Liquids Unless Their Identity Can be Kept Confidential and Criteria is Established for Their Permissible Use

The *NPRM* observes that certain propellant and coolant liquids may be used in satellites that, if released into space, could remain in droplet form.¹⁷ The *NPRM* therefore proposes to require that satellite license applicants disclose the planned use of such liquids in satellites.¹⁸ The proposed rule would require the submission of a statement that the satellite operator has assessed and limited the probability that the release of such liquids could become a source of debris.¹⁹ The text of the *NPRM*, however, suggests that satellite operators would also have to “identify” any such liquids.²⁰

Boeing has two concerns with this proposal. First, if satellite operators are required to identify the liquids involved, then the Commission must ensure that an adequate mechanism is in place to permit the submission of such information to the Commission on a confidential basis. The development and use of new spacecraft propellants is a highly competitive field. Satellite manufacturers such as Boeing treat their propellants as highly proprietary and would not permit its customers to make public disclosures regarding their characteristics.

Second, if the Commission adopts such an information disclosure requirement, it should provide clear and objective guidance regarding when the use of such liquids would be permitted. The development of new propellants and coolants has the potential to greatly increase the in-service life expectancy of satellites, while also reducing their weight and cost. Certain new

¹⁷ See *NPRM*, ¶ 22.

¹⁸ See *id.*, ¶ 23.

¹⁹ *NPRM*, Appendix A, § 25.114(d)(14)(iii).

²⁰ *Id.*, ¶ 23.

propellants can also reduce the risk of an accidental explosion. Therefore, the Commission should articulate that the use of such liquids is presumptively appropriate if reasonable measures are taken to prevent their release.

C. The Commission Should Adopt a Presumption That Each Satellite Should be Designed Such that the Probable Risk of a Collision With a Large Object is No More Than 0.001

Boeing concurs with the *NPRM* proposal to adopt a presumption that each satellite should be designed in a manner that the probable risk of a collision with a large object should not exceed 0.001. This metric has long been the standard recommended by NASA²¹ and it is appropriate for the Commission’s regulatory purposes. The addition of the 0.001 metric will provide much needed transparency to Section 25.114(d)(14)(iii), which has long required satellite license applicants to conduct an assessment regarding the potential for a collision with large debris without articulating a numeric threshold that the Commission would consider acceptable.

In proposing to adopt the NASA Standard, however, the Commission should act consistently in adopting the relevant standard in its entirety. Specifically, as the *NPRM* acknowledges, Section 4.5-1 of the NASA Standard clearly indicates that it was developed for use on a per-satellite basis.²² The *NPRM*, however, requests comment on applying the NASA Standard on an aggregate basis²³ and the draft rule that is included in Appendix A of the *NPRM*

²¹ See NASA Technical Standard, *Process for Limiting Orbital Debris*, NASA-STD-8719.14A (with Change 1) (May 25, 2012), available at <https://standards.nasa.gov/file/2707/download?token=jFflsudM> (last visited April 2, 2019) (“*NASA Standard*”).

²² See *NPRM*, ¶ 26.

²³ See *id.*, ¶ 26 (indicating that “[w]e invite comment on whether this metric should also be applied on an aggregate, system-wide basis, *i.e.*, 0.001 for an entire constellation”).

makes reference to “space station(s)”,²⁴ potentially suggesting that the metric could be applied to a constellation in the aggregate. The *NPRM* provides no analysis or justification for suggesting that the NASA Standard should be substantially modified in this manner. The *NPRM* also fails to consider the substantial costs that would result for operators of large satellite constellations if the rule was interpreted on an aggregate basis. Instead, the only discussion that is included in the *NPRM* addressed the incentives for evasion that would result if the metric was applied on an aggregate basis.²⁵

Although Boeing agrees that evasion would likely occur, Boeing is far more concerned about the fact that the *NPRM* has proposed to substantially change the NASA Standard without providing any reason or analysis supporting this proposal. Therefore, Boeing urges the Commission to implement the 0.001 metric on a per-satellite basis as envisioned by NASA.

In a similar manner, the *NPRM* requests comment on whether the Commission’s rules “should specify a size for what is considered a large object, or whether we should continue our current case-by-case approach, which in practice typically results in consideration of catalogued objects.”²⁶ Section 4.5-1 of the NASA Standard, however, clearly indicates that the objects that are relevant to the 0.001 metric are those that are “larger than 10 cm in diameter.”²⁷ Therefore, if the Commission is going to adopt NASA’s 0.001 metric (which seems appropriate), the Commission should also adopt NASA definition of the large objects that must be considered in ascertaining compliance.

²⁴ *Id.*, Appendix A, Section 24.114(d)(14)(iv)(A)1.

²⁵ *See id.*

²⁶ *Id.*

²⁷ *NASA Standard*, at 32, Section 5.4.2 (providing the details of Requirement 4.5-1).

In expressing support for use of the >10 cm definition of large objects, Boeing acknowledges the *NPRM*'s observation that the original >10 cm threshold may have been based on the minimum size that could be tracked and catalogued.²⁸ Further, more advanced tracking capabilities may enable the detection and monitoring of even smaller objects in the future.²⁹ The Commission, however, should not change the definition of large object for purposes of this rule unless it concurrently considers whether corresponding changes to the 0.001 metric may be needed to ensure that satellite operator compliance with this rule does not become excessively burdensome or expensive.

Boeing also supports other proposals included in this portion of the *NPRM*. For example, Boeing agrees that it is appropriate and consistent with NASA practices to treat any spacecraft that is maneuverable as posing zero or near zero risk of a collision with large objects. Satellite operators have adequate incentives to manage the operation of their maneuverable spacecraft in order to avoid large objects, both while in service and during the disposal process.

D. The Commission Should Adopt a Presumption That Each Satellite Should be Designed Such that the Probable Risk of it Becoming a Source of Orbital Debris as a Result of a Collision With Small Objects is No More Than 0.01

Boeing concurs with the *NPRM* proposal to adopt a presumption that each satellite be designed in a manner that the probable risk of it becoming a source of orbital debris as a result of a collision with small objects should not exceed 0.01.³⁰ This metric has also long been

²⁸ *See id.*

²⁹ *See id.*

³⁰ The Commission should not, however, require satellite applicants to “certify” compliance with the 0.01 metric. To this end, Boeing acknowledges that the draft rules in Appendix A do not include a certification requirement, but the text of the *NPRM* makes reference to a certification

recognized by NASA and will provide much needed transparency to Section 25.114(d)(14)(i), which requires satellite license applicants to conduct an assessment regarding the potential for a collision with small debris without articulating a numeric threshold that the Commission would consider acceptable.

In proposing to adopt the NASA Standard, however, the Commission should again act consistently in adopting the relevant standard in its entirety. Specifically, as the *NPRM* acknowledges, the NASA Standard clearly indicates that it was developed for use on a single satellite³¹ and therefore the Commission should implement its rule in this same manner.³² The Commission should also adopt its proposal that small debris includes any object smaller than 10 centimeters,³³ which would correspond with the proposed definition of large objects.

The Commission, however, should recognize the limited efficacy of this analysis with respect to satellites that would be launched into higher orbits. The modeling software for small debris is largely based on extrapolations from measurements conducted below 600 kilometers and can be expected to be increasingly unreliable at higher orbits. Nevertheless, conducting the analysis and mandating compliance with the 0.01 metric remains valuable.

requirement. *See id.*, ¶ 27. The Commission has never required individual certifications for its orbital debris disclosures and no justification has been presented to adopt one in this instance.

³¹ *See NPRM*, ¶ 26.

³² *Id.*, Appendix A, Section 24.114(d)(14)(ii) (once again indicating in the draft rules that are included in Appendix A of the *NPRM* that the requirement would be applied to “space station(s)”).

³³ *See id.*, ¶ 26.

E. The Commission Should Update its Disclosure Requirements for NGSO System Applicants With Respect to Their Coordination With Other Potentially Affected NGSO Systems

Boeing concurs with the proposed changes to the Commission’s orbital debris rules with respect to the information disclosures required of NGSO satellite system applicants seeking to operate in an orbit that is similar in altitude or other relevant characteristic with existing or planned NGSO satellite systems.³⁴ Further, this rule should apply to all NGSO satellite systems and not just to those in LEO orbit.³⁵

In updating this portion of its rules, however, the Commission should clarify that this disclosure requirement only applies to other NGSO satellite systems “the normal operations of which” poses a risk of collision.³⁶ This change would be appropriate to exclude consideration of transfer and storage orbits, or the results of anomalies, which, while important, extend beyond what can or should be considered by a new applicant when considering the sharing of orbital resources with existing or planned satellite systems. Instead, transfer, storage and anomaly situations should be uniformly addressed on a case-by-case basis between satellite system operators using post-licensing inter-operator coordination. This issue is addressed further in Section II.X. of these comments.

Boeing also concurs with the Commission’s tentative conclusion that any risk of collision between active satellites—including those operating within their normal parameters—should be

³⁴ See *id.*, ¶ 28.

³⁵ See *id.*

³⁶ Thus, the proposed rule could read in relevant part, “[t]he statement must identify any planned and/or operational space stations the normal operation of which ~~that~~ may raise a collision risk, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision.”

addressed in the first instance through inter-operator coordination.³⁷ This is the approach that has been employed for decades between operators of GSO satellites and no reason exists to employ a different approach with respect to constellations of NGSO satellites.

F. The Commission Should Limit Any New Information Disclosure Requirements Regarding Satellites Transiting the Altitude of the International Space Station

Boeing agrees with the Commission's proposal that NGSO systems that will operate above the nominal altitude of the International Space Station ("ISS") should disclose any operational constraints that may be caused to the ISS or other manned spacecraft and the strategies that would be used to avoid collisions with manned spacecraft.³⁸ The Commission, however, should not adopt this new information disclosure requirement unless it concurrently adopts objective criteria regarding the avoidance measures that would be presumptively sufficient to warrant Commission approval. For example, the Commission should conclude that an operator's planned avoidance measures are presumptively sufficient if they avoid any impact to the ISS or other manned spacecraft absent an anomaly. Consistent with this, the Commission should not adopt a requirement that satellites deployed above the nominal ISS altitude must have propulsion-based maneuvering capabilities. Instead, other measures involving such techniques as atmospheric drag could be sufficient to support an adequate showing.

³⁷ *See id.*

³⁸ *See id.*, ¶ 30.

G. The Commission Should Not Attempt to Regulate the Highly Sensitive Orbital Altitude Selection Process

Boeing does not support the Commission's proposal to require NGSO system applicants that seek to deploy their constellation in the LEO region above 650 km to specify why it has chosen that particular orbit.³⁹ The selection of a particular orbit for an NGSO satellite system involves a complex trade analysis that balances such factors as the ground coverage of the satellite, the size and density of coverage beams, the latency of the signals, the geographic areas served, and the flyover repetition of each spacecraft. The Commission should not involve itself in these business and technical considerations. Instead, the Commission should accept that satellite operators will have valid business and technical reasons to operate NGSO constellations above an altitude of 650 kilometers and such proposals should not be questioned as long as the satellite operator complies with the various orbital debris mitigation requirements specified in the Commission's rules.

Further, this is another instance where the Commission is proposing the adoption of a new information disclosure requirement without concurrently adopting objective criteria regarding the justifications that would be adequate to support the launch of an NGSO system in LEO altitude above 650 kilometers. Therefore, the Commission should refrain from adopting this proposal.

H. The Commission Should Refrain From Adopting an Information Disclosure Requirement Regarding the Length of the Deorbit Process Unless it Adopts an Objective Criteria as Guidance

Boeing does not support the Commission's proposal, in its current form, to require a statement from satellite license applicants addressing their rationale for selecting an orbit that could result in the satellites remaining in orbit for a long period of time relative to the time needed

³⁹ See *id.*, ¶ 31.

to perform their mission.⁴⁰ First, as noted above, the Commission should not inject itself into the complex decision process that is undertaken by satellite operators in selecting an operational orbit for their NGSO satellites.

Second, to the extent that the Commission adopts a limit on the length of time that an NGSO satellite can remain in orbit following the end of its mission, this limit should be based on objective criteria. For example, NASA has long maintained a standard that satellites and other debris should remain in space for no more than 25 years following the end of their mission.⁴¹

The *NPRM* requests comment on substantially reducing this period for NGSO satellites that have relatively brief operational missions, such as prohibiting the orbital lifetime from exceeding the mission lifetime by more than a factor of two.⁴² Unfortunately, this proposal may have the unintended consequence of prompting satellite operators to develop mission plans that are more lengthy than necessary (thus correspondingly increasing the allowable orbital lifetime).

As an alternative, the Commission may want to consider adopting orbital lifetime limits that are directly related to the altitude chosen by the satellite operator. Thus, satellites launched to altitudes below the ISS could continue to be subject to the 25 year orbital lifetime standard, while satellites launched to altitudes above the ISS potentially should be subject to a briefer period, such as a presumptive limit of no more than 15 years absent justification for a longer period (such as a very long mission plan). In this way, the Commission will address the primary concern expressed in this portion of the *NPRM*, *i.e.*, limiting debris that could harm the ISS or other manned spacecraft.

⁴⁰ See *id.*, ¶ 32.

⁴¹ See *NASA Standard*, Requirement 4.3-1a.

⁴² See *NPRM*, ¶¶ 32 and 59.

I. The Commission Should Not Adopt Rules Addressing the Potential Use of Highly Congested Orbits

Boeing agrees with the Commission's observation that it may be advisable for new NGSO satellite constellations to avoid deployment in altitudes that have very high amounts of debris in order to minimize risk.⁴³ Boeing, however, does not believe that it is necessary or appropriate for the Commission to adopt regulations addressing this decision process.

The Commission's rules should be limited to addressing instances in which satellite operators may not have sufficient economic incentive to act appropriately and the outcome of inappropriate decisions may be externalized by causing harm to the public interest. This is why it is appropriate for the Commission to adopt rules governing post-mission disposal practices, to address the lack of economic incentives to remove retired satellites from space.

In this case, however, the Commission is proposing a rule that would address the decision making process of satellite operators regarding the initial orbital placement of their satellite constellation. Given the enormously expensive nature of NGSO satellite constellations, satellite operators clearly have adequate incentive to select initial orbits that are sufficiently free of hazards. Alternatively, some satellite operators may choose to use such orbits if they invest in sufficient measures to facilitate the safety of their satellites, particularly as other orbits become congested with existing satellite systems. In any event, the Commission should refrain from injecting itself in this decision process and should instead conclude that a satellite operator is entitled to make its own business and technical decision regarding its chosen orbit as long as its proposal satisfies that Commission's other rules regarding operational control and the management and removal of retired satellites.

⁴³ See *id.*, ¶ 33.

J. The Commission Should Not Require that All NGSO Satellites Operated Above a Certain Altitude Must Have Propulsion Capabilities

Boeing opposes the adoption of a blanket rule that all NGSO satellites that would operate above a certain altitude must have propulsion capabilities.⁴⁴ Other techniques have been used (and more are being developed) to permit small satellites to proactively maneuver without the use of propulsion and thus enable collision avoidance. For this same reason, Boeing disagreed with the Commission's tentative conclusion in its rulemaking proceeding on streamlined licensing for small satellites that maneuvering techniques relying "primarily on drag" are "insufficient to support deployment at higher altitudes."⁴⁵ The Commission should instead allow NGSO satellite applicants to provide demonstrations that the techniques that they propose to employ (potentially including drag) are adequate to enable responsive maneuvers. The Commission should also consider proposals to use other techniques and strategies, including operating in elliptical orbits or using inclinations and orbital periods that would avoid conflicts with the ISS and similar facilities, in order to make unnecessary the incorporation of maneuvering capabilities in the design of an NGSO satellite.

K. The Commission Should Explore the Adoption of Limits on Variations in NGSO Orbits for Large Satellite Systems

As Boeing has argued in other proceedings, the Commission should consider the adoption of limits in the maximum variations that are permissible in the orbits of NGSO satellite systems. For example, on August 16, 2016, the FCC's International Bureau sent a letter to Boeing requesting information regarding "the accuracy to which [its] NGSO space station orbital parameters will be

⁴⁴ See *id.*, ¶ 34.

⁴⁵ See Streamlining Licensing Procedures for Small Satellites, IB Docket No. 18-86, *Notice of Proposed Rulemaking*, FCC 18-44, ¶ 34 (April 17, 2018).

maintained, including apogee, perigee, inclination, orbital altitude, and right ascension of the ascending node(s).”⁴⁶ Boeing responded by explaining that its constellation will use “frozen orbits” to minimize the long-term changes in eccentricity and argument of perigee. Thus, “[t]he eccentricity of the constellation will be maintained to within 5×10^{-4} of the planned value” and the inclination will be permitted to vary “within a range of ± 0.15 degrees.”⁴⁷ Further, “[t]o control the mean parameters of the orbit over the constellation life, spacecraft station keeping will be utilized to maintain relative position of the satellites to within ± 3 kilometers in the radial direction, ± 10 kilometers in the in-track direction, and ± 2 kilometers in the cross-track direction.”⁴⁸

In providing this information, Boeing is not suggesting that this level of accuracy should be required of all NGSO system operators. Boeing observes, however, that the Commission granted market access for the OneWeb NGSO satellite system even though OneWeb indicated only that the altitude (apogee and perigee) of its constellation will be “maintained to less than one percent” of the mean semi-major axis (“SMA”) and inclination “will be maintained to less than 1° of this target.”⁴⁹ Boeing has previously questioned whether such large variations in SMA or inclination are likely to occur due to normal orbit perturbations. Boeing also previously questioned whether allowing such large variations would impair the ability of multiple NGSO FSS systems to share scarce orbital resources. In this regard, Article 44 of the ITU Constitution

⁴⁶ Letter from Jose P. Albuquerque, Chief, Satellite Division, to Bruce A. Olcott, Jones Day, IBFS File No. SAT-LOA-20160622-00058, at 3 (Aug. 16, 2016).

⁴⁷ Letter from Bruce A. Olcott, Jones Day, to Jose P. Albuquerque, Chief, Satellite Division, IBFS File No. SAT-LOA-20160622-00058, at 8-9 (Sept. 16, 2016).

⁴⁸ *Id.*

⁴⁹ See OneWeb Orbital Debris Mitigation Plan, File No. SAT-LOI-20160428-00041, at 3, § 4.2 (Nov. 10, 2016).

directs that Member States shall bear in mind that orbital resources “are limited natural resources” that must be used “rationally, efficiently, and economically” so that different countries “may have equitable access” to them.⁵⁰ To fulfill this obligation, the Commission should consider the adoption of appropriate limits on orbital variation to facilitate sharing of scarce orbital resources between multiple NGSO constellations.

L. The Commission Should Adopt Reasonable Measures to Ensure the Successful Tracking of NGSO Satellites

Boeing supports the Commission’s proposal that all NGSO satellite system applicants disclose information to the Commission regarding the ability of space situational awareness facilities to track the proposed satellites using radar or other means.⁵¹ As the Commission appropriately observes, satellites that have dimensions of 10 centimeters or more are trackable using traditional means, regardless of the altitude.⁵²

Boeing also does not object to a Commission requirement that NGSO satellite system applicants disclose whether they plan to employ active tracking (such as the use of a beacon), or passive tracking (using ground based radar).⁵³ If the Commission adopts such an information disclosure requirement, however, it should concurrently confirm that it does not require the use of active tracking systems and, as long as an applicant’s satellites can be tracked using passive measures, a statement in this regard will be sufficient. Further, if a satellite operator chooses to employ an active tracking approach, there will be no need for the Commission to secure

⁵⁰ ITU Constitution, Article 44.

⁵¹ *See NPRM*, ¶ 36.

⁵² *See id.*

⁵³ *See id.*

confirmation that the active telemetry marker will be unique since satellite operators will have adequate incentive to ensure that they can distinguish the telemetry beacons of their own satellites as compared to all others.

Boeing also has no objection to the Commission requiring NGSO satellite system operators to provide information to the U.S. Strategic Command's Joint Space Operations Center (or any successor organization) regarding the initial deployment, ephemeris data and any planned maneuvers for its satellites.⁵⁴ Additionally, Boeing has no objection to a Commission requirement that NGSO satellite applicants certify that, upon receipt of a conjunction warning, the satellite operator will take "all possible steps" to mitigate collision risk.⁵⁵ This said, this is another area where Commission regulation is entirely unnecessary because all satellite operators have sufficient incentives to avoid collision risks.

The Commission should also require all NGSO system operators to make their ephemeris data available to other NGSO system operators to facilitate coordination with other systems. The Commission, however, should permit satellite operators to decide how to electronically share their data, rather than mandating participation in the Space Data Association or requiring ongoing (rather than just initial) data submissions to the U.S. Strategic Command's Joint Space Operations Center.

⁵⁴ *See id.*, ¶ 37.

⁵⁵ *See id.*, ¶ 38.

M. The Commission Should Not Adopt Information Disclosure Requirements Regarding Maneuverability and the Anticipated Avoidance Maneuvers for Satellites Absent Objective Guidance Regarding the Methods and Frequency that are Presumptively Acceptable

The Commission proposes to adopt information disclosure requirements regarding the extent of the maneuverability of NGSO satellites and an assessment of the number of collision avoidance maneuvers that the satellite operator anticipates will be required.⁵⁶ The *NPRM*, however, does not provide adequate detail regarding the manner in which the Commission may use this information. The *NPRM* tentative concludes that “such information can assist us in our public interest determination, in particular regarding any burden that other operators would have to bear in order to avoid collisions and false conjunction warnings.”⁵⁷ The *NPRM*, however, does not provide guidance regarding the number of avoidance maneuvers (either by the applicant or other operators) that would presumptively be deemed to be acceptable.

In raising this concern, Boeing acknowledges that the number of maneuvers that will be needed for NGSO systems will almost certainly increase in the future as orbital resources in the LEO region become more congested with new and potentially overlapping NGSO systems. Further, as the frequency of such avoidance maneuvers increases, confidence within the satellite industry regarding the ability of satellite operators to conduct these maneuvers on a safe and reliable basis should also increase. Therefore, it may be appropriate for the Commission to conclude that, although satellite operators will be required to disclose such information in their license applications, this information will not be used to withhold or condition the authorization

⁵⁶ See *NPRM*, ¶ 39.

⁵⁷ *Id.*

of any NGSO satellite system at least until the satellite industry (and the Commission) gains more experience regarding of frequency and reliability of such avoidance techniques.

N. The Commission Should Not Adopt Information Disclosure Requirements Addressing the Launch of Multiple Satellites on a Single Launch Vehicle

The *NPRM* discusses the challenges that exist with respect to the launch of multiple satellites on a single launch vehicle with respect to ensuring that the satellites do not collide with each other or otherwise interfere with their respective orbits.⁵⁸ In fact, the launch of multiple satellites on a single launch vehicle has become the norm within the satellite industry with respect to medium and small satellites. This is because, despite the obvious challenges, shared launch vehicles provide substantial economies of scale and permit the launch of smaller satellites much more quickly at much less expense. Further, the use of shared launch vehicles ultimately reduces the generation of orbital debris by limiting the number of launches that are required to complete a constellation.

Despite the prevalence of shared launch vehicles, the *NPRM* does not identify any unfavorable trend with respect to collision events involving the ejection of multiple satellites from a shared launch vehicle. This is because, as the *NPRM* appears to acknowledge, shared launch vehicles have become a very successful tool in the growth and development of the commercial launch industry. Further, as the *NPRM* acknowledges, satellite operators often do not know at the time of licensing whether shared launch vehicles will be used for all or a portion of their satellites.⁵⁹

⁵⁸ See *id.*, ¶ 40.

⁵⁹ See *id.*, ¶ 41.

Given these facts, no reason exists for the Commission to adopt an information disclosure requirement regarding the use of shared launch vehicles by NGSO system licensees. Further, the Commission should also refrain from adopting disclosure requirements for shared launch vehicles because no evident need exists for the Commission to adopt guidelines regarding whether the use of such launch vehicles is permissible and, absent the adoption of such guidelines, the adoption of an unguided information disclosure requirement of this nature would be inappropriate.

O. The Commission Should Not Adopt Design and Fabrication Reliability Requirements for Large NGSO Satellite Constellations

The NPRM requests comment on whether it should impose design and fabrication reliability requirements on NGSO satellites.⁶⁰ In raising this idea, the *NPRM* references a letter filed by NASA addressing the SpaceX NGSO systems in which NASA suggested that “[f]or discussion purposes, a design and fabrication reliability on the order of 0.999 or better per spacecraft may be prudent to mitigate the risk of malfunction in a 4,000+ spacecraft constellation.”⁶¹

Boeing questions whether such a design and fabrication reliability requirement would be achievable for existing or upcoming generations of NGSO satellites. Normally, the reliability of a satellite and its components is determined based on its prior use in existing satellite systems. Thus, Boeing anticipates that it may be able to achieve a high level of reliability in its NGSO satellites through the use of many components that were previously used by Boeing in other GSO

⁶⁰ See *id.*, ¶¶ 42-43.

⁶¹ Letter from Anne E. Sweet, NASA Representative on the Commercial Space Transportation Interagency Group, Program Executive, Launch Services Office, Human Exploration and Operations Mission Directorate, NASA to Marlene Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20161115-00118, SAT-LOA-20161115-00121 at 2 (June 26, 2017).

and NGSO satellites it manufactured. Even with its decades of experience, however, it is unlikely that Boeing could achieve a reliability level of 0.999 percent on a newly developed NGSO satellite, particularly on a cost effective basis. Boeing anticipates that satellite manufacturers with less experience may have even greater difficulty achieving a 0.999 percent reliability level. Further, as the *NPRM* acknowledges, imposing a very high design and fabrication reliability requirement would inevitably force satellite manufacturers to rely solely on older, well tested satellite designs and thus prevent innovation and improvements.⁶²

Given these facts, the Commission should refrain from adopting a reliability requirement for NGSO satellites used in large constellations until the satellite industry has developed a great deal more experience developing and launching NGSO satellite systems and a track record is developed on what is achievable on a cost-effective basis.

P. The Commission Should Adopt Reasonable Requirements for Reentry Disposal Reliability

Boeing agrees with the Commission's proposal to require the disclosure of the expected reliability of the disposal measures that will be employed for atmospheric re-entry of NGSO satellites and the method by which that expected reliability was derived.⁶³ In furtherance of the goal of transparency and predictability in the Commission's rules, Boeing also supports the Commission's proposal to adopt a reliability metric of 0.9 for individual satellites. The Commission may also consider the adoption of a higher metric for individual satellites in large constellations, which should be defined as constellations of 100 satellites or more.⁶⁴ The higher

⁶² See *NPRM*, ¶ 43.

⁶³ See *id.*, ¶ 46.

⁶⁴ See *id.*

metric for individual satellites in large constellations, however, should not exceed 0.95, which is the maximum of what is achievable for satellites that employ lengthy and often complex disposal sequences (such as using multiple electric propulsion maneuvers). These targets generally can be achieved by installing redundant systems that support critical operations.

Such measures will benefit the goal of decreasing orbital debris, albeit likely at a higher cost for U.S. authorized satellite operators. The Commission, however, should not impose a reliability factor in excess of 0.9 for individual NGSO satellites in smaller constellations (*i.e.*, those involving less than 100 satellites) because such a requirement would be extremely stringent and is generally not achievable for satellites that employ active propulsive maneuvers for disposal following a potentially lengthy mission life.

Q. The Commission Should Not Require the Launch of NGSO Satellites to an Initial Altitude of Below 650 Kilometers

Boeing does not support the Commission's proposal to require that all satellites that will operate at an altitude of 650 km or higher be initially deployed into orbit below 650 km and then raised to a higher orbit following testing. This is not the most effective approach to test the reliability of new satellites. First, it only serves to verify the initial functions of a new satellite, not its longer term reliability. Existing verification and qualification approaches prior to the launch of a new satellite have already proven sufficient to reduce infant mortality in new satellites to reasonable levels. Requiring the initial use of a lower orbit would also impose substantial costs on satellite operators and reduce the available fuel for station keeping and, with it, mission life.

The more appropriate approach is for the operator of a new constellation of NGSO satellites to launch a few test satellites and operate them for a reasonable period (*i.e.*, 3 to 6 months) to verify their performance. This is the approach that has been used by nearly all (if not all) operators of NGSO satellite systems, including most recently by OneWeb. Further, the Commission does not

need to impose a regulatory obligation that operators of NGSO satellite systems begin with the launch of a few test satellites because—as is evident by industry practices—satellite operators already have sufficient incentive to employ this approach in order to avoid the significant costs that would result from replicating the same unanticipated fault in large numbers of satellites.

Further, the Commission should not dictate the length of such test operations using a small number of satellites and, in particular, the Commission should not require that such tests continue for “a certain number of years.”⁶⁵ Once a few test satellites have been placed into orbit, satellite operators are usually able to determine fairly quickly whether the satellites are operating as intended or whether any anomalies are apparent that may necessitate an extended period of monitoring. Therefore, the Commission should continue to permit satellite operators to determine on their own when their initial satellites have been tested sufficiently rather than arbitrarily impose a minimum duration for such test operations.

R. The Commission Should Not Require Satellites to Automatically Initiate Disposal Measures Upon a Loss of Power or Contact With the Ground

Boeing does not support the Commission’s proposal to require that NGSO satellites be designed to automatically initiate disposal procedures in the event of a power loss or a lack of communication with the ground.⁶⁶ Instead, other measures are much more effective and reliable—including some identified in the *NPRM*⁶⁷—such as the inclusion of redundancy in critical systems, ongoing monitoring of the health of the spacecraft and its disposal function, and the manual initiation of the satellite’s disposal if serious anomalies are identified.

⁶⁵ See *id.*, ¶ 48.

⁶⁶ See *id.*, ¶ 49.

⁶⁷ See *id.*

In contrast, for most satellites, an automatic initiation function is unlikely to be effective due to the complexity and duration of the disposal process and the likelihood that the cause of the power or communications loss may also disable the automatic disposal function, even if it is powered by a separate system. In this regard, Boeing anticipates that the suggestion made by the European Space Agency regarding the use of automated disposal systems was expressed largely in the context of spacecraft with relatively simple disposal procedures.⁶⁸ For example, a spacecraft with a high impulse propulsion system would be more capable of initiating its disposal with a short maneuver sequence, but would likely be unable to complete the disposal absent an active ground control system. In contrast, many newer spacecraft employ a significantly more complex disposal initiation sequence. For example, a spacecraft with electric propulsion will require multiple propulsive burns over an extended period of time to complete the disposal sequence. Any attempt to rely on the success of such complex systems to complete disposal following the failure of the primary power or communication on the spacecraft would seem very unreliable and would not elevate the probability of successfully completing the disposal process.

Instead, the Commission should solely impose its above-discussed requirement that the satellite be designed with a reliability of 0.9 that the satellite disposal will be effective. Such an approach would be technically neutral and would permit satellite manufacturers to continue to determine the more cost effective and reliable means to achieve this requirement.

⁶⁸ See Letter from Johann-Dietrich Wörner, Director General, European Space Agency, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 16-408 at 3 (Sept. 15, 2017).

S. The Commission Should Continue to Encourage the Development of Direct Retrieval, But the Technology is Not Ready for Commercial Use

Boeing shares with the Commission its significant interest in the potential use of direct retrieval systems to avoid the use of storage orbits or atmospheric reentry to dispose of retired satellites.⁶⁹ Boeing is closely monitoring technical developments in this area and their potential use to retrieve Boeing satellites from space at some point in the future. For example, Boeing is participating in the Consortium for Execution of Rendezvous and Servicing Operations (“CONFERS”), which is an industry-led initiative partially financed by the Defense Advanced Research Projects Agency (“DARPA”) to research, develop, and publish non-binding, consensus-derived technical and operations standards for rendezvous and proximity operations, including satellite retrieval, replacement, and robotic servicing.⁷⁰

For the foreseeable future, however, the direct retrieval of satellites from orbit (LEO or otherwise) is not feasible from a technical or economic standpoint. Further, it has yet to be demonstrated that direct retrieval methods under development can operate in a manner that would reliably ensure that they do not create more orbital debris than they eliminate. Therefore, although the Commission should continue to encourage developments in this area, the Commission should not yet incorporate the direct retrieval option into its rules. Instead, the Commission should continue to expect that operators of LEO constellations will rely on atmospheric reentry to dispose of retired satellites.

⁶⁹ See *NPRM*, ¶¶ 53-54.

⁷⁰ See <https://www.satelliteconfers.org/about-us/> (last visited March 28, 2019).

T. The Commission Should Adopt Reasonable Requirements Addressing Reentry Periods and Reentry Tracking of Retired Satellites

As addressed above in Section II.H. of these comments, if the Commission decides to reduce the period during which a satellite may remain in orbit following the conclusion of its operating mission, the reduced period should be based on objective criteria and not necessarily be based on the length of the operational mission.⁷¹ For example, the Commission might consider adopting orbital lifetime limits that are directly related to the altitude chosen by the satellite operator, with a 25 year limit at altitudes below the ISS and a shorter period (perhaps 15 years) for altitudes above the ISS.

In computing the anticipated post-mission orbital life, satellite operators should be permitted to take into consideration any factors that may legitimately impact the length of the reentry period. In this regard, no reason exists to preclude satellite operators from considering the potential impacts of solar activity,⁷² the long term variations of which have proven to be predictable with a reasonable level of certainty.

With respect to the reentry period following the end of a satellite's mission,⁷³ satellite operators should not be required to maintain communication links and active tracking with the satellite following the end of the mission unless they had initially indicated in their satellite application that active tracking would be used (rather than passive tracking) to monitor the location of the spacecraft. Further, the satellite operator should be required to continue to obtain spacecraft tracking information for retired satellites only if the satellite operator's original

⁷¹ See *NPRM*, ¶ 59.

⁷² See *id.*

⁷³ See *id.*

calculations regarding the safe reentry of the satellite depended on the operator's ability to conduct evasive maneuvers during the reentry process.⁷⁴ Otherwise, active tracking by the satellite operator would seem unnecessary.

U. The Commission Should Adopt New Information Disclosure Requirements on Reentry Casualty Risk, But Only if the Commission Concurrently Quantifies the Presumptively Acceptable Risk

Since 2004, the Commission has required satellite license applicants to submit an assessment regarding whether any portion of the satellite would survive reentry and, if so, an estimate of the resulting probability of human casualty.⁷⁵ The *NPRM* proposes to supplement this requirement in two ways. First, the rules would assume that, consistent with the NASA Standard, any object with an impacting kinetic energy in excess of 15 joules would have a potential to cause a human casualty. Second, the rules would require the use of the NASA Debris Assessment Software (or a higher fidelity model) to conduct this assessment.

Boeing supports both of these additions to the Commission's rules because they are consistent with the requirements that have been previously communicated to satellite license applicants informally by FCC staff. Thus, the proposed additions would improve the Commission's rules by making them more transparent and predictable.

This said, it is unclear to Boeing why the *NPRM* does not propose the adoption of a maximum casualty risk that the Commission would deem presumptively acceptable. The *NPRM* acknowledges that the NASA Standard includes a "requirement" that the risk of human casualty from surviving debris "shall not exceed 0.0001" both with respect to controlled and uncontrolled

⁷⁴ *See id.*

⁷⁵ *See* 47 C.F.R. § 25.114(d)(14)(iv).

reentry.⁷⁶ The *NPRM*, however, does not propose the codification of this requirement in its draft rules. Instead, the *NPRM* says nothing about how the FCC staff will evaluate assessments of uncontrolled reentries and, for controlled reentries, the *NPRM* says only that “we anticipate evaluating such plans on a case-by-case basis.”⁷⁷

The Commission should not adopt a heightened reporting requirement of reentry casualty risk without concurrently providing guidance to satellite license applicants (and FCC staff) regarding the maximum human casualty that would be deemed to be presumptively acceptable. Absent such guidance, the adoption of the proposed reporting requirement could produce arbitrary and capricious outcomes and would harm the interests of the U.S. aerospace industry.

Further, the *NPRM* requests comment on whether its assessment of human casualty risk should be conducted on a per-satellite basis or aggregated to an entire satellite system.⁷⁸ The NASA Standard, however, clearly indicates that its requirements are intended to be applied on a per-object basis, whether that object is a satellite or a piece of debris from a satellite.⁷⁹ Therefore, the Commission should not, on the one hand, indicate that it is going to adopt the NASA Standard and, on the other hand, make substantial changes to its terms. Instead, the Commission should act consistently in adopting the NASA requirement, both with respect to the manner in which its assessment is conducted and the presumptive acceptability of the outcome achieved. The *NPRM* presents no justification to act otherwise.

⁷⁶ See *NASA Standard*, Section 4.7.2.1.

⁷⁷ See *NPRM*, ¶ 60, n.145.

⁷⁸ See *id.*, ¶ 62.

⁷⁹ See *NASA Standard*, Section 4.7.2.1.

V. The Commission Should Codify its Policies for GSO License Term Extensions

Boeing supports the *NPRM* proposal to codify in the Commission's rules its long standing practices with respect to applications to extend the license terms for GSO satellites.⁸⁰ As discussed in previous sections of these comments, codifying long standing Commission practices increases transparency and predictability for FCC licensees.

Although Boeing does not object to the Commission's proposal that GSO license extensions should be presumptively limited to no more than five additional years, Boeing believes that GSO operators should be permitted to overcome this presumption by showing that a particular satellite has not shown any evidence of a potential failure and is based on a class of satellites that have survived reliably for longer periods in the past. Also, if the Commission does impose a five year limit, it should modify its proposed language for Section 25.121 of its rules to clearly indicate that, although license extensions will be limited to five years or less, licensees can seek multiple such extensions if the circumstances warrant. Such additional language is appropriate given the increasingly longer periods that GSO satellites are able to safely operate, particularly with the introduction of new fuel types, such as electronic propulsion.

W. The Commission Should Refrain From Adopting Special Disclosure Requirements for Satellites Engaged in Proximity Operations

Boeing acknowledges that there is heightened interest within the satellite industry on the capability of operating satellites and other space vehicles in proximity with each other. These capabilities can lead to more intensive use of orbital resources and support satellite and retrieval and resupply missions, all of which the Commission should encourage.

⁸⁰ See *NPRM*, ¶¶ 63-65.

Boeing has no objection to a requirement that satellite license applicants disclose to the Commission when such proximity operations are planned.⁸¹ The Commission, however, should not adopt unique information disclosure requirements for such operations. Instead, the Commission will already receive adequate information regarding any risks for collisions between space vehicles through its other existing and proposed orbital debris mitigation reporting requirements.

Further, no need exists to report plans for proximity operations to the Air Force's 18th Space Control Squadron.⁸² Instead, the currently proposed reporting requirement (involving the initial deployment, ephemeris data and any planned maneuvers of satellites)⁸³ should be sufficient to facilitate the Squadron's tracking mission.

Finally, the Commission should also refrain from adopting additional information disclosure requirements for satellite operators planning proximity operations because the *NPRM* has offered no guidance regarding the manner in which such information will be assessed by the Commission staff and how they will determine which operations are acceptable. Heightening this concern is the fact that many satellite operators and manufacturers, including Boeing, treat their satellite flight management and proximity operations techniques as highly proprietary. Therefore, confidential treatment would be required for the details of any such disclosures that may be required. Given this, the Commission should refrain from adopting any special information disclosure requirements for proximity operations and instead rely on its other existing and proposed debris mitigation rules to address these issues.

⁸¹ *See id.*, ¶ 68.

⁸² *See id.*

⁸³ *See id.*, ¶ 37.

X. The Commission Should Update its Rule for Orbit Raising to Cover Both GSO and NGSO Satellite on a Fully Coordinated Basis

Boeing concurs with the *NPRM* proposal to expand the reach of the Commission's rules for orbit raising so that they apply to both GSO and NGSO satellites.⁸⁴ Further, the Commission should do away with the constructive fiction that such orbit raising maneuvers can be performed on a non-interference and unprotected basis. Instead, in order to ensure that an orbit raising maneuver is completed successfully, the operation must be fully coordinated with other satellite operators in order to ensure that communications with the transiting satellite are not lost and that such communications do not interfere excessively with other satellites. Consistent with this, Boeing supports the modification of the Commission's rules to eliminate language indicating that communications with transiting satellites must "accept interference" from all other satellites⁸⁵ and communications with a transiting satellite must "cease operations" if unacceptable interference to other satellites occurs.⁸⁶ Additionally, the requirement to coordinate orbit raising operations should be applied to NGSO satellites as well.

Y. The Commission Should Not Adopt a Requirement that Satellite Telemetry, Tracking and Command Communications Must be Encrypted

The Commission should refrain from adopting a requirement that telemetry, tracking and command communications for satellite operations be encrypted. As the *NPRM* acknowledges, most satellite operators already do encrypt their control links, likely including the operators of all

⁸⁴ See *id.*, ¶¶ 70-71.

⁸⁵ 47 C.F.R. § 25.282(c).

⁸⁶ 47 C.F.R. § 25.282(b).

of the types of satellites that the *NPRM* proposes to cover.⁸⁷ Thus, rather than try to make a blanket determination regarding the circumstances in which such encryption is justified, the Commission should conclude that satellite operators have adequate incentive to encrypt their control communications. Thus, federal regulation in this area is unnecessary.

III. THE COMMISSION SHOULD NOT IMPOSE INDEMNIFICATION OR INSURANCE REQUIREMENTS ON SATELLITE OPERATORS

The *NPRM* proposes to adopt a requirement that satellite operators enter into contractual agreements of indemnification with the United States addressing any costs incurred by the government resulting from accidents involving the operator's satellites.⁸⁸ In support of this proposal, the Commission observes that, under international law, each country is potentially liable for damage caused by orbital debris resulting from its licensed satellite systems.⁸⁹

The Commission should refrain from adopting its indemnification proposal because it is entirely unnecessary. First, the *NPRM* fails to reference any example where the U.S. government has faced liability or incurred damages as a result of orbital debris from a commercial satellite system licensed by the Commission. Thus, this is a very complex solution in search of a non-existent problem.

Second, even if an accident did result in the future involving an FCC-licensed satellite system and the U.S. government faced liability, the government would not need a contractual indemnification agreement to secure recovery from the FCC-licensed satellite operator. Instead, as the *NPRM* acknowledges, the Commission's review of an applicant's debris mitigation plan, or

⁸⁷ See *id.*, ¶ 74.

⁸⁸ See *id.*, ¶ 76.

⁸⁹ See *id.*

grant of a license, does not alter any liability of the applicant or licensee.⁹⁰ Accordingly, the U.S. government would be fully within its rights to maintain a civil tort claim against the FCC licensee under a Claim of Contribution,⁹¹ Claim of Equitable Apportionment,⁹² or a Claim of Equitable Tort Indemnification.⁹³ Therefore, no need exists to undertake the complex and expensive process of drafting contractual indemnification language that would mirror these existing legal concepts.

The Commission should also refrain from requiring satellite operators to secure insurance covering liability for damage resulting from orbital debris.⁹⁴ First, it is far from clear whether the cost of such insurance would actually discourage the generation of orbital debris. Most

⁹⁰ See *id.*, ¶ 77.

⁹¹ See, e.g., *Barrett v. United States*, 853 F.2d 124, 130-31 (2d Cir. 1988) (United States permitted to maintain a tort claim of contribution against the State of New York for its liability in the death of a patient in 1953 at the New York State Psychiatric Institute who was injected with chemicals without his consent in the course of a chemical warfare experiment conducted with the U.S. Army); *United States v. Hawaii*, 832 F.2d 1116, 1118 (9th Cir. 1987) (permitting the United States to maintain a contribution claim against the State of Hawaii for its contributory role in third party injuries caused by a jeep driven by a sergeant in the Hawaii National Guard); *Bradford v. United States*, 2018 U.S. Dist. LEXIS 51263 (W.D. KY, 2018) (United States permitted to maintain tort claim of contribution against a boat operator for its share of liability for the loss of three passengers when the boat capsized); *United States v. St. Louis Univ.*, 2007 U.S. Dist. LEXIS 84915 (S.D. IL, 2007) (United States permitted to sue defendant university for contribution resulting from its liability in a medical malpractice and wrongful death action); *Danz v. United States*, 1976 U.S. Dist. LEXIS 11823 (S.D. FL, 1976) (United States permitted to maintain a claim of contribution from the estate of a pilot following a plane crash that was deemed partially the fault of air traffic controllers and partially the fault of the deceased pilot); *Portel v. United States*, 85 F. Supp. 458 (S.D. NY, 1949) (United States permitted to maintain a claim of contribution against the employer of an individual who was injured while servicing a U.S.-owned vessel for its share of the liability).

⁹² See, e.g., *Bethel Native Corp. v. DOI*, 208 F.3d 1171 (9th Cir. 2000) (United States permitted to maintain a third-party claim for equitable apportionment of tort liability against the State of Alaska for its role in the burn injuries to an individual resulting from an oil spill).

⁹³ See, e.g., *Williams v. United States*, 469 F. Supp. 2d 339 (E.D. VA, 2007) (United States was able to maintain a claim for equitable tort indemnification against a bus service transporting Navy sailors regarding injuries to a sailor).

⁹⁴ See *NPRM*, ¶ 80.

insurance policies provide compensation for actual and quantifiable damages, and the premiums for such insurance relate closely with the estimated size and frequency of such damages. In contrast, although orbital debris is a significant and growing problem, the vast majority of orbital debris never results in any damage that could be the subject of a reimbursable insurance claim. Therefore, it would be very difficult to identify a correlation between the cost of such insurance and the scope of the efforts by the insured to avoid the generation of debris. Accordingly, the Commission should refrain from adopting an insurance requirement if its purpose is to incentivize satellite operators to avoid the generation of orbital debris. The Commission should also refrain from adopting an insurance requirement given the fact that no example exists of any damage caused by orbital debris from an FCC-authorized satellite that resulted in a compensable injury or claim against the satellite operator, the U.S. government, or a third party.

IV. THE COMMISSION SHOULD REFRAIN FROM ADOPTING THE OTHER PROPOSALS RAISED IN THE REGULATORY IMPACT ANALYSIS OF THE *NPRM*

The *NPRM* requests comment on a number of other options to address the generation of orbital debris. None of these proposals, however, warrant serious consideration and, to the extent that they were not addressed previously in these comments,⁹⁵ they are briefly addressed below.

First, the *NPRM* seeks comment on regulations that would force a reduction in the number of satellites launched under U.S. jurisdiction.⁹⁶ The *NPRM* posits that this could reduce the

⁹⁵ The *NPRM* proposals on changes to operations and disposal procedures, *see id.*, ¶ 94, are addressed in Section II of these comments, the proposals regarding economic incentives, *see id.*, ¶ 95, are addressed in Section III, the proposals regarding active collision avoidance, *see id.*, ¶ 96, are addressed in Section II, M., and the proposals regarding active debris cleanup, *see id.*, ¶ 97, are addressed in Section II, S. and additionally in this section.

⁹⁶ *See id.*, ¶ 92.

generation of orbital debris.⁹⁷ In reality, however, such a proposal would simply concede the leadership position of the United States in the growth of the commercial space industry. A corresponding portion of the launch capacity eliminated by the United States would be replaced by other countries. Thus, rather than increase the role of the Commission in regulating orbital debris, this proposal would have the opposite effect.

Second, the Commission should not attempt to regulate the design of commercial satellites.⁹⁸ Leaving aside the question of whether the Commission has the technical expertise for such a role, any effort to place the commercial satellite manufacturing industry under government control would stifle innovation and growth. As the *NPRM* acknowledges, “[d]riven by innovation from both established commercial enterprises and new entrepreneurial endeavors, a new landscape for the private space industry is emerging, sometimes referred to as ‘New Space.’”⁹⁹ The *NPRM* proposal would eliminate this growth, at least in the United States.

Third, the Commission should not require satellite operators to engage in active debris cleanup.¹⁰⁰ As discussed previously in these comments, although technologies are under development for the removal of orbital debris from space, none of these techniques are sufficiently mature to be employed on a reliable or cost effective basis. Further, some of the proposals that have been explored may generate more debris than is removed. Therefore, the Commission should refrain from taking any action in this area and continue to permit commercial innovation to focus on this issue in an effort to identify an appropriate solution.

⁹⁷ *See id.*

⁹⁸ *See id.*, ¶ 93.

⁹⁹ *Id.* ¶ 1.

¹⁰⁰ *See id.*, ¶ 97.

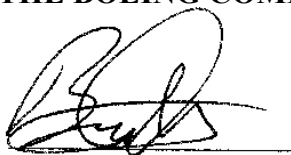
V. CONCLUSION

In updating its rules addressing the mitigation of satellite orbital debris, the Commission should employ transparent and predictable requirements and ensure that its rules are carefully coordinated with international regulatory bodies and with other U.S. federal agencies that have particular expertise in these areas. Such measures are necessary to ensure that the Commission's regulation in this area does not impede the growth and development of the commercial space industry in the United States.

Respectfully submitted,

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